

# Methods and System Design of the FOI Information Fusion Demonstrator – IFD03

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# Outline

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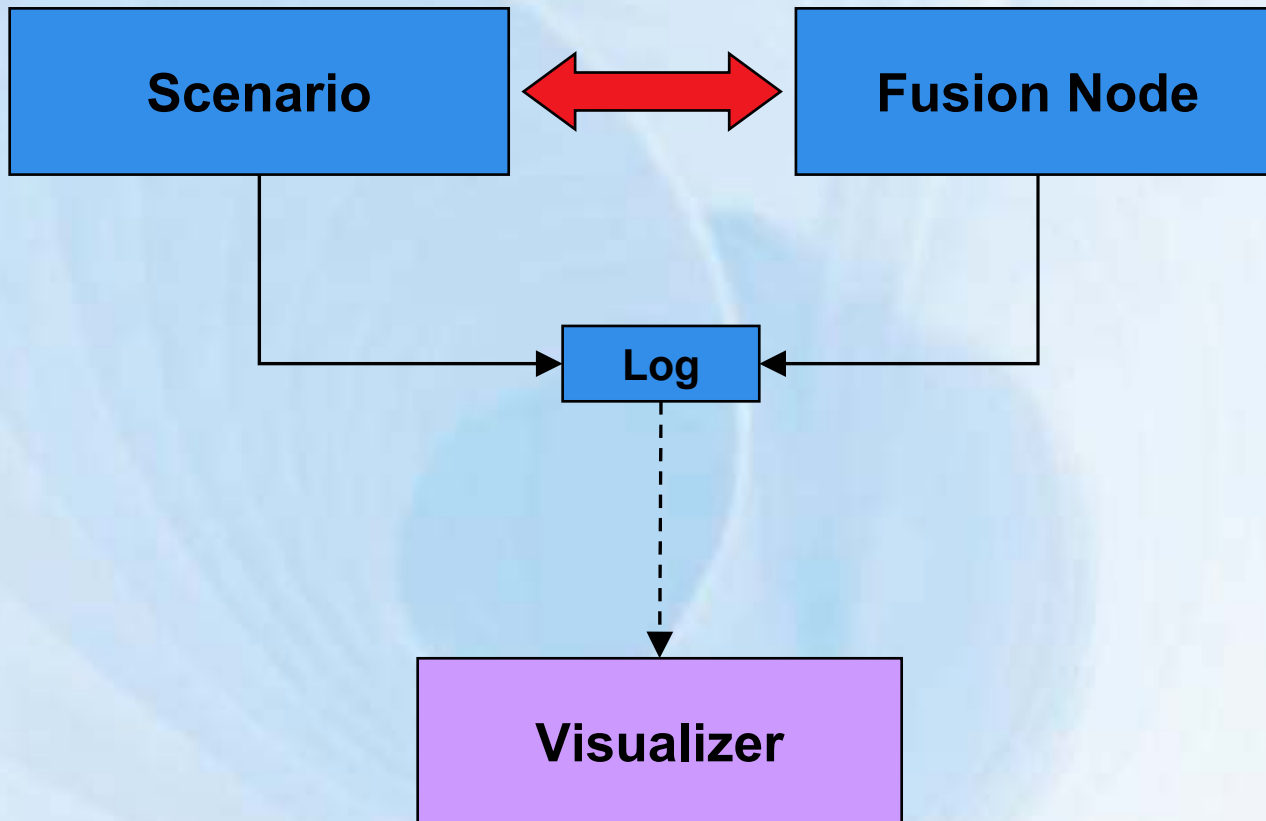
# Introduction

## ■ What is the IFD03?

- ***A concept*** demonstrator for information fusion methodology in a future Network Based Defence C4ISR system
- **Focus on analysing intelligence reports at the division level in a ground warfare scenario**

## ■ Reasons for building the IFD03

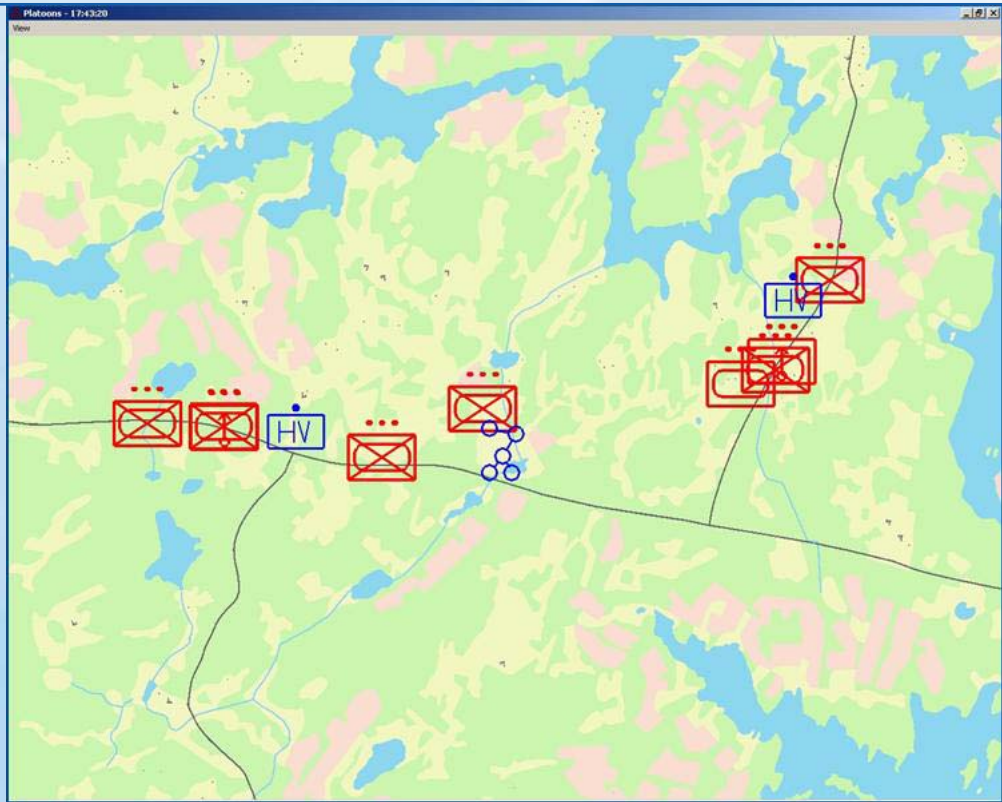
- **Explore how fusion methods can be combined in a single system**
- **Show information fusion in a concrete fashion to our customers**



# Information Fusion Methods

- **Force Aggregation**
  - Clustering
  - Classification
- **Ground Vehicle Tracking**
  - PHD Particle Filter
- **Sensor Resource Management**
  - Random Set Simulations

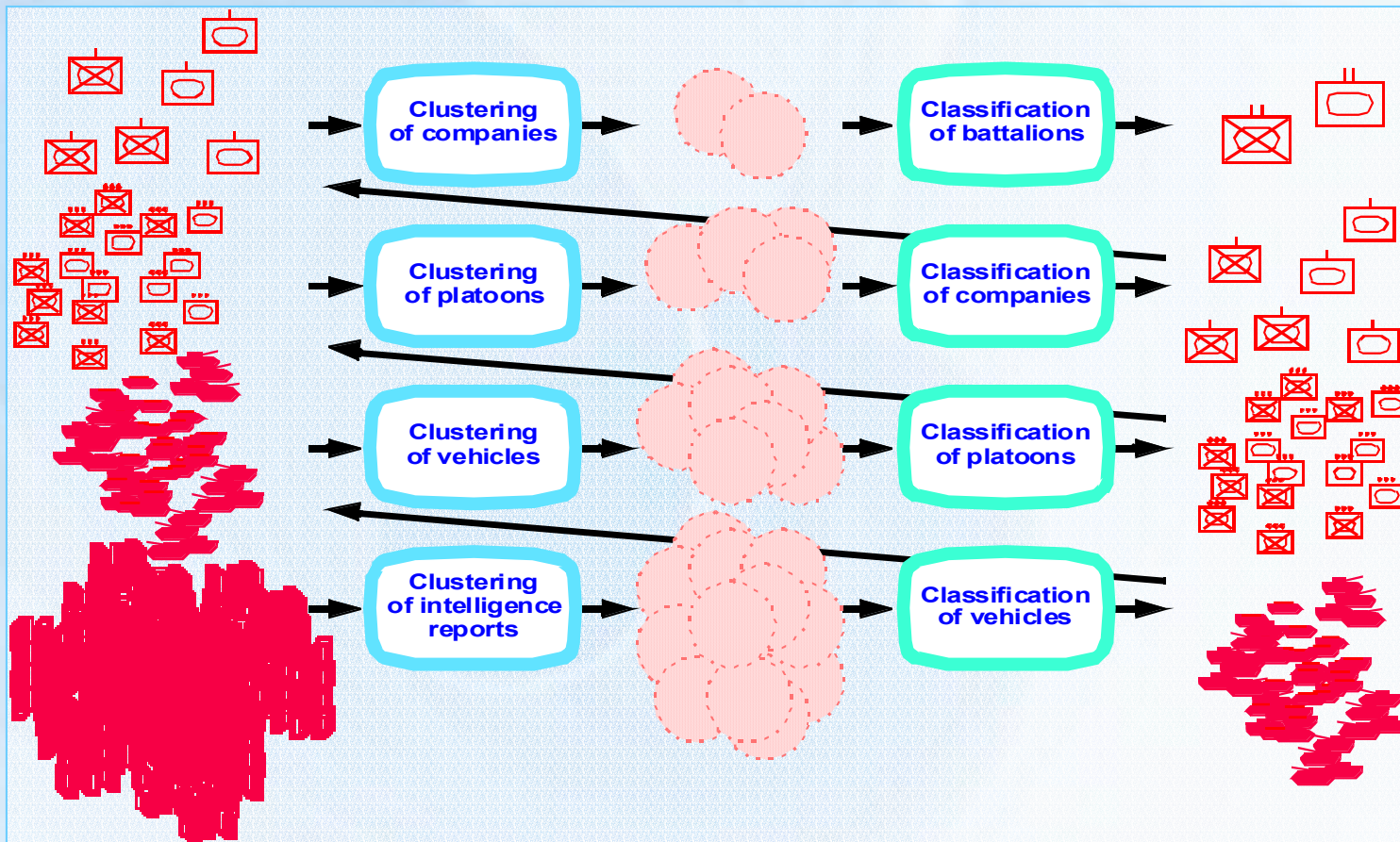
# Force Aggregation



- **PROBLEM:** Determine positions and organizational structures of enemy units
- **SOLUTION:** Dempster-Shafer Clustering and Classification



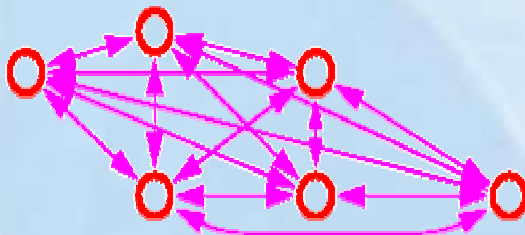
# Aggregation = Clustering + Classification





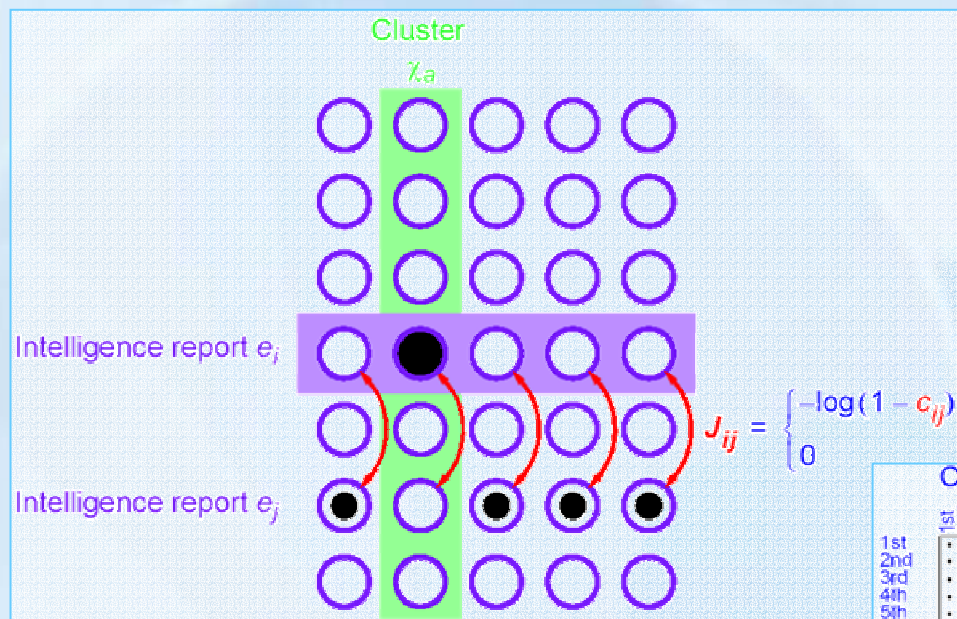
# Clustering

- Evaluate all pairs of intelligence reports



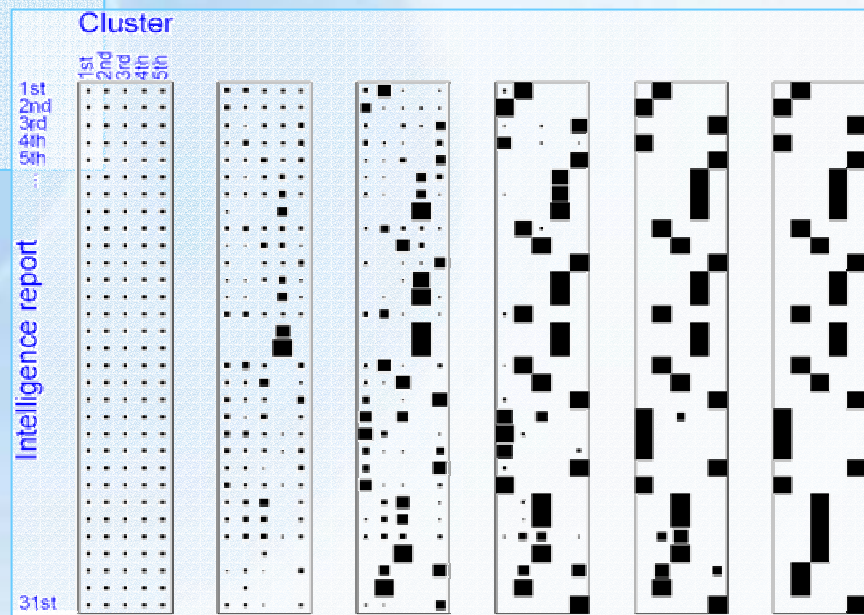
- Find whatever is against that two reports are referring to the same object
  - Wrong type of vehicle? (Dempster-Shafer conflict)
  - Is distance too long?
  - Wrong direction?
- this yields a potential conflict between each pair of intelligence reports

# Clustering - Potts Spin neural network

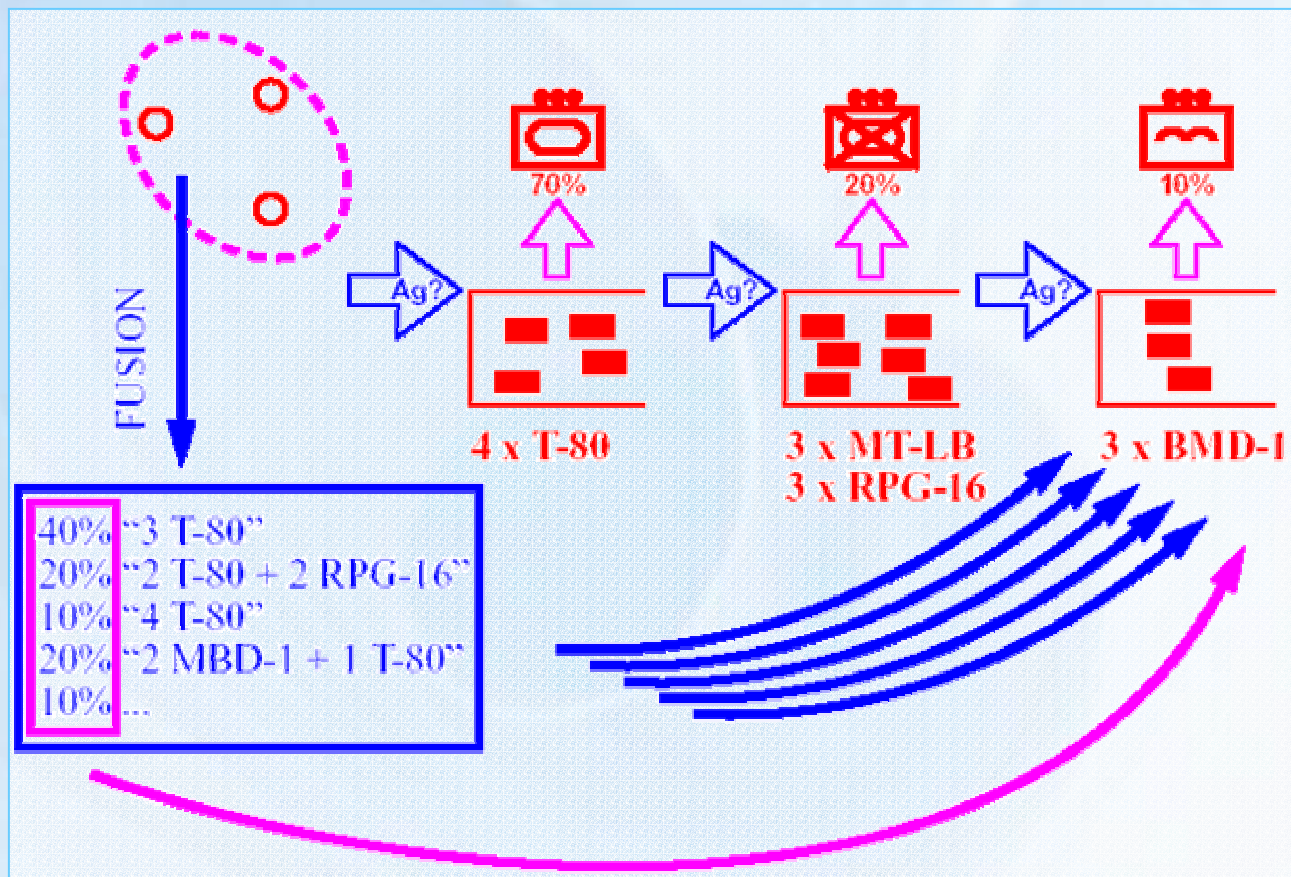


Cluster example:

31 intelligence reports are clustered into 5 clusters

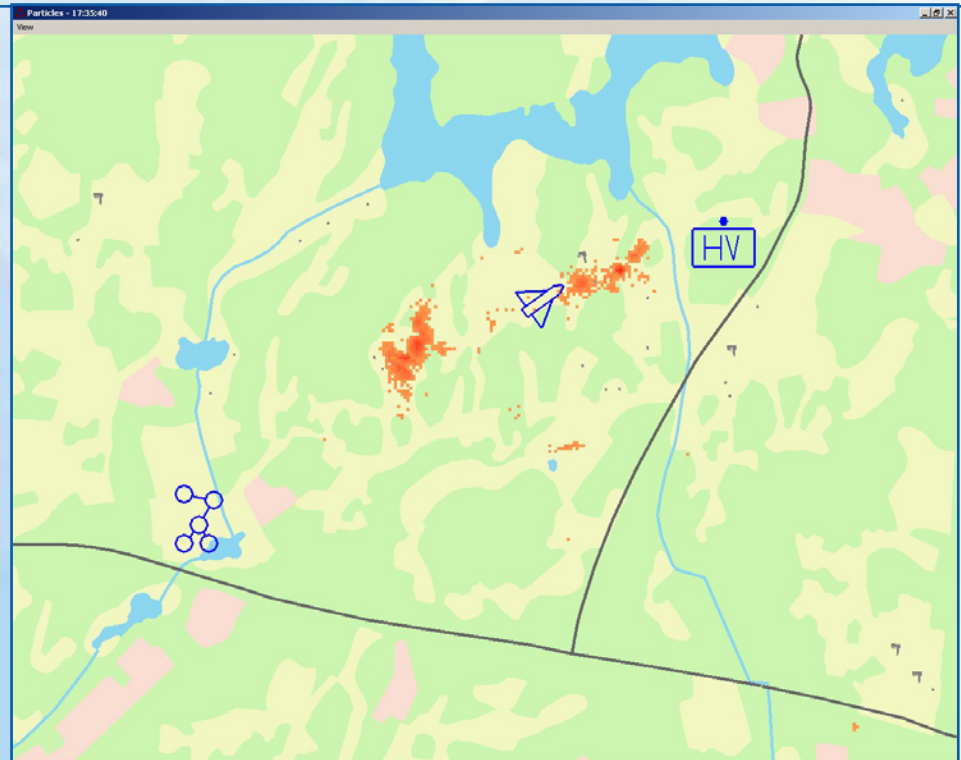


# Classification





# Ground Vehicle Tracking



- **PROBLEM:** Tracking of a large number of vehicles in terrain from incomplete observations.
- **SOLUTION:** PHD Particle Filtering (PHD = Probability Hypothesis Density)

# PHD Particle Filtering – Approach

- **We track the first moment of joint distribution, i.e., PHD**
  - Integral of PHD over an area is expected # targets – compare with PDF with integral 1
  - Avoids combinatorial explosion – good for large number of vehicles
- **Here – particle filter implementation**
  - No need for analytical motion and observation models
  - Suitable for non-linear problems

# PHD Particle Filtering – Illustration

- A PHD is represented by  $N \times 500$  particles
- $N$  is expected number of targets

Posterior at  $t-1$

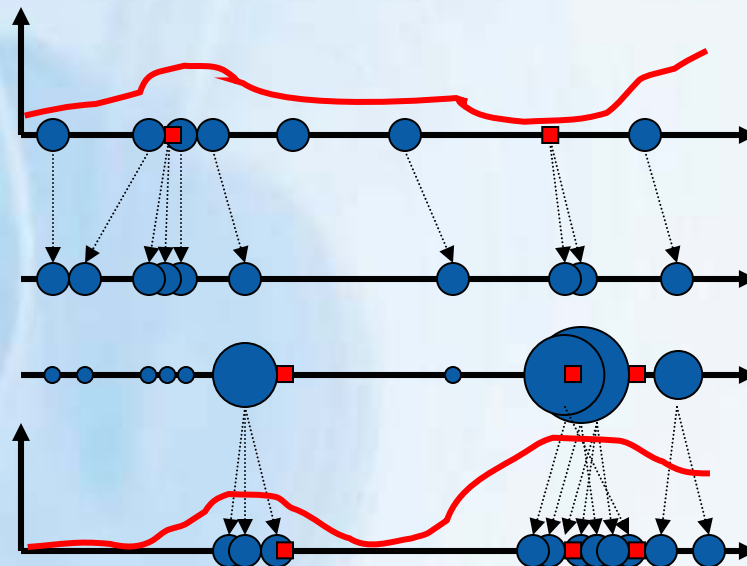
Propagate

Prior at  $t$

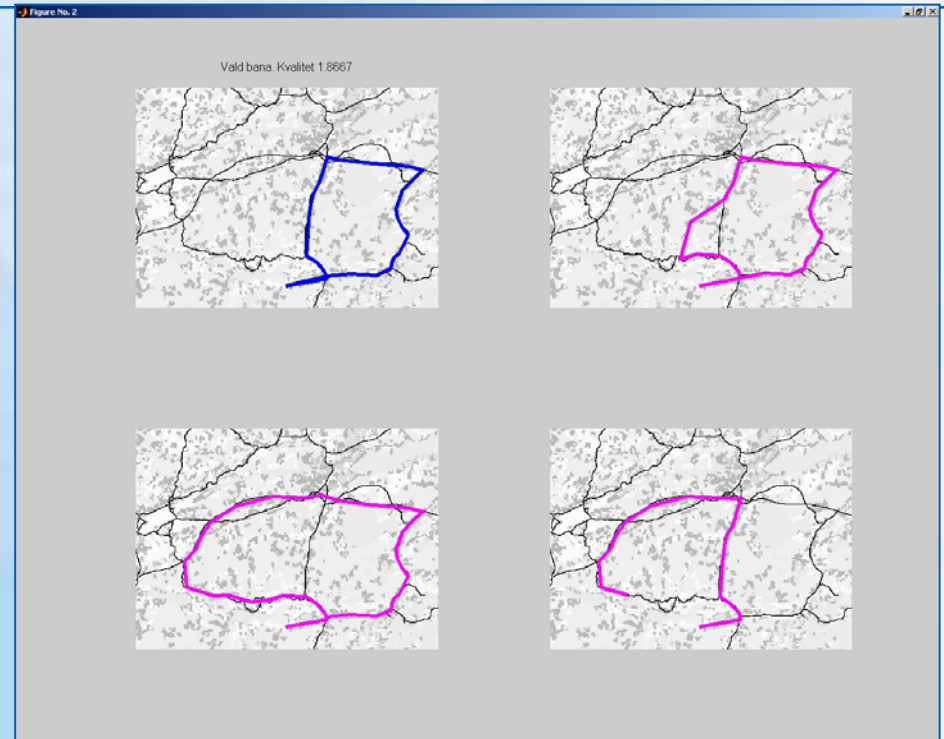
Multiply with SUM of likelihoods

Resample

Posterior at  $t$



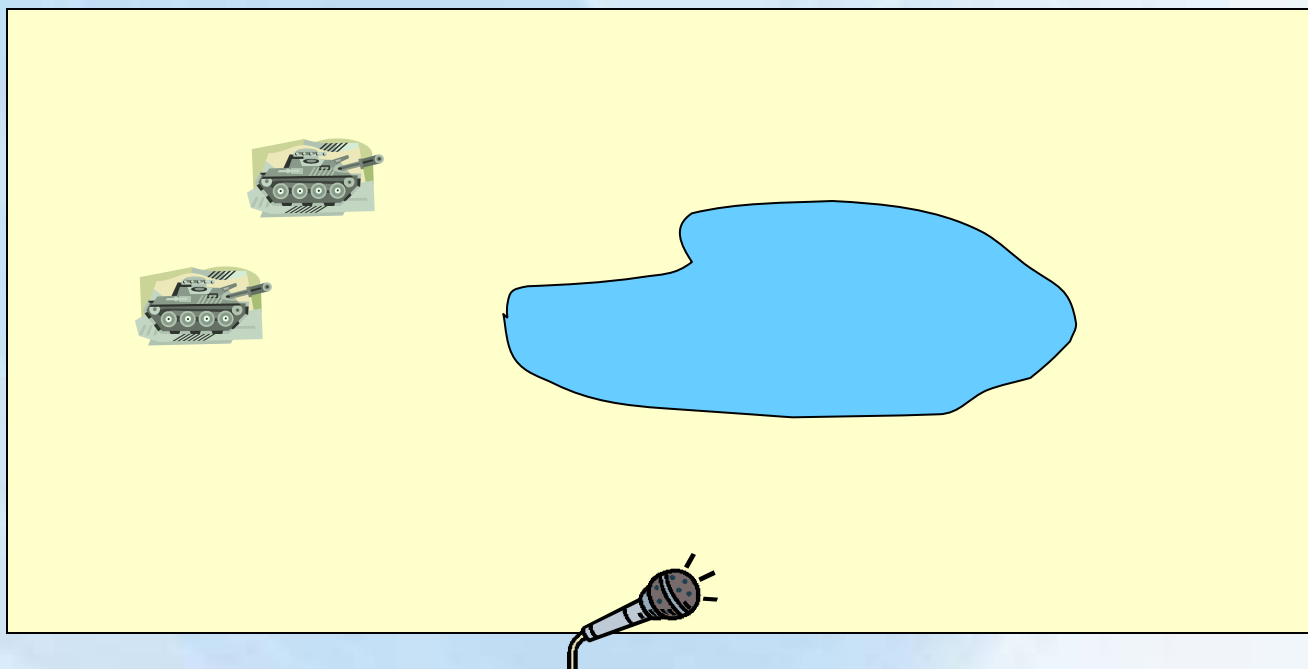
# Sensor Resource Management



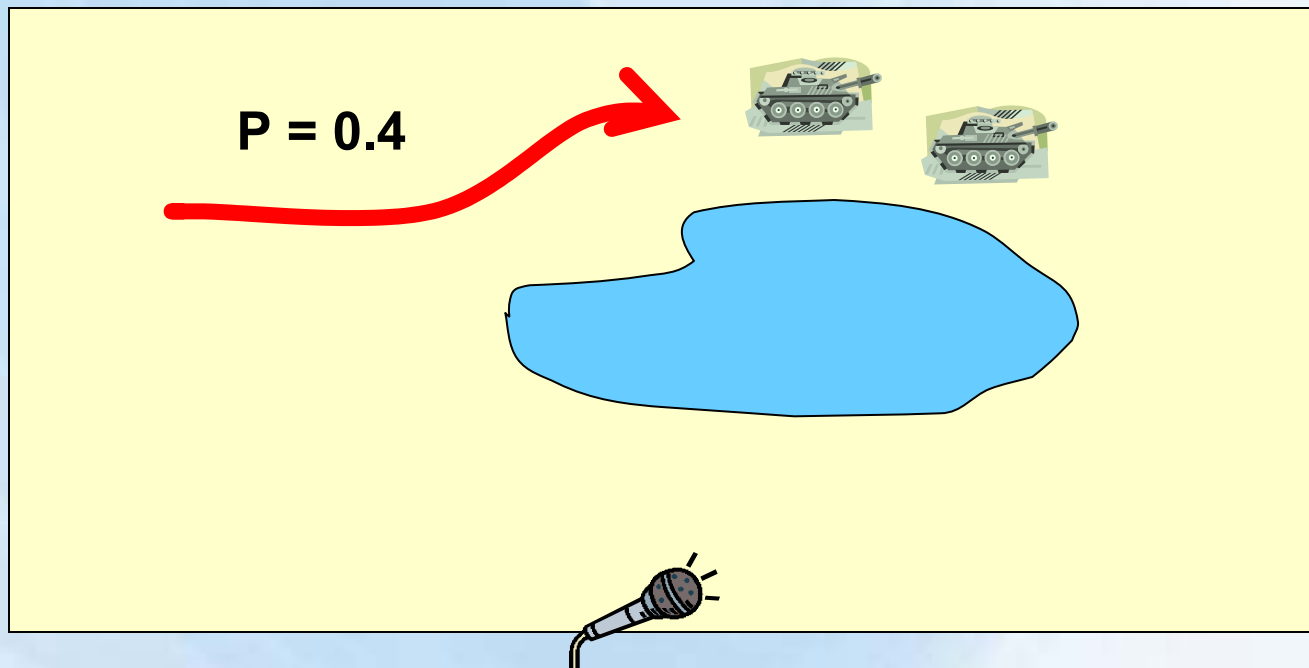
- **PROBLEM:** Given positions and possible strategies for the enemy, find an optimal sensor control policy
- **SOLUTION:** Evaluate sensor allocations by simulating different futures



# Enemy positions now

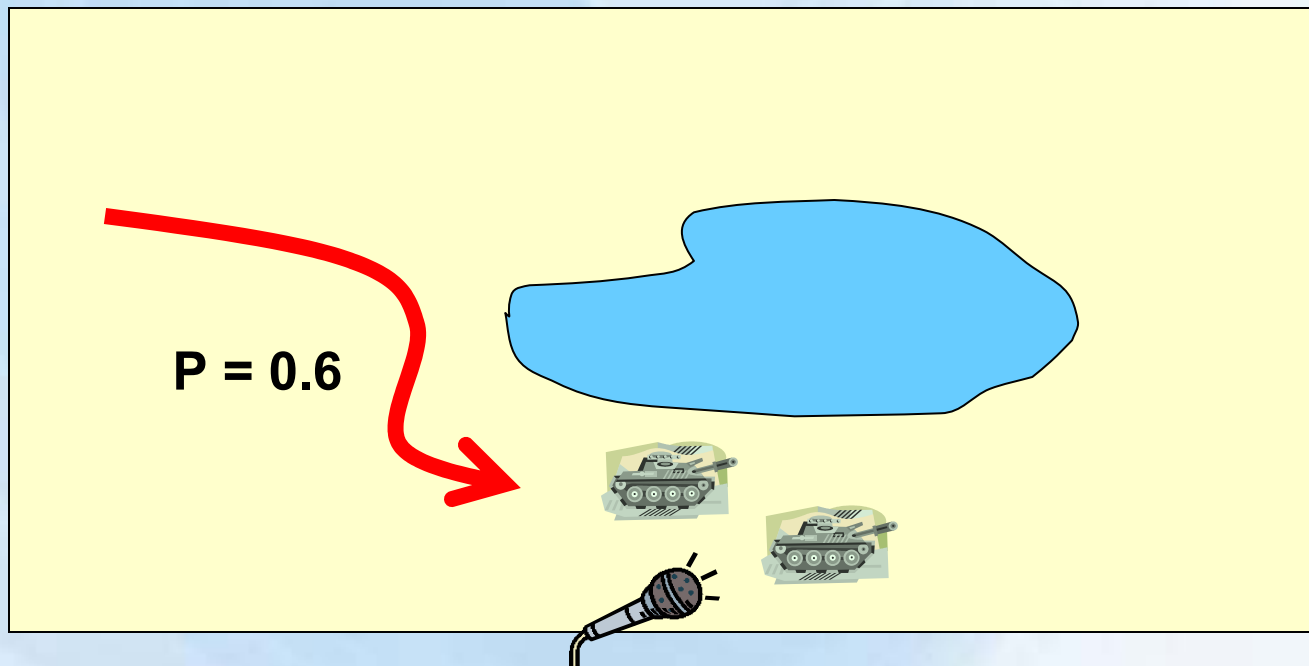


# One possible future path



Sensor doesn't hear tanks!

## Another possible future path

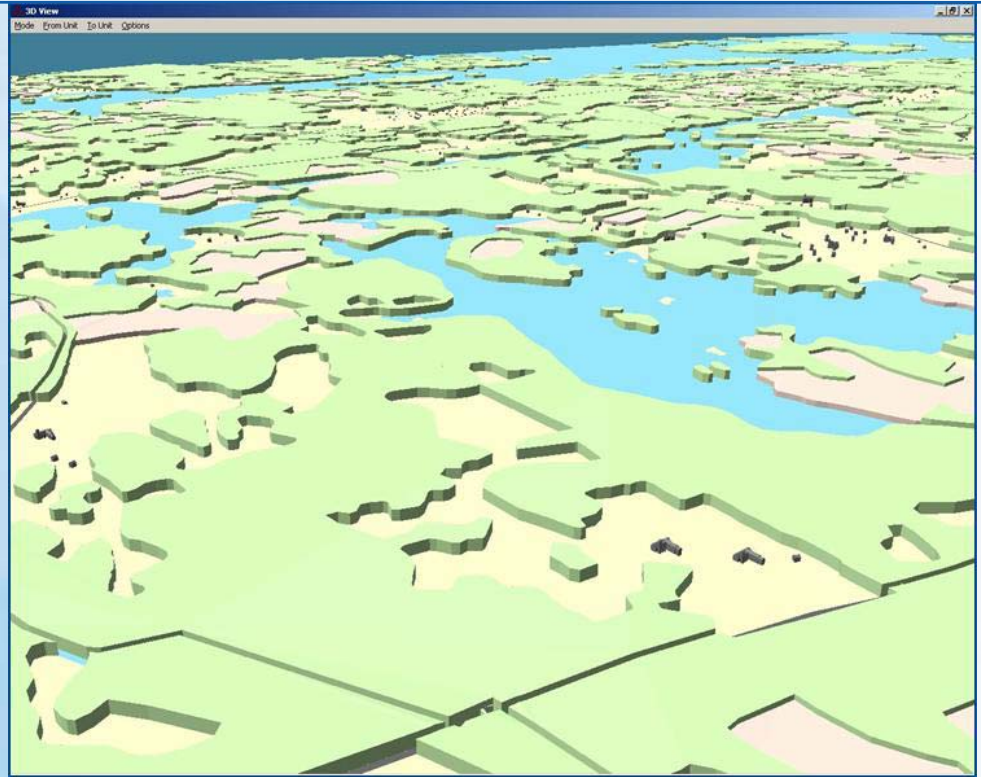


Tanks are observed!

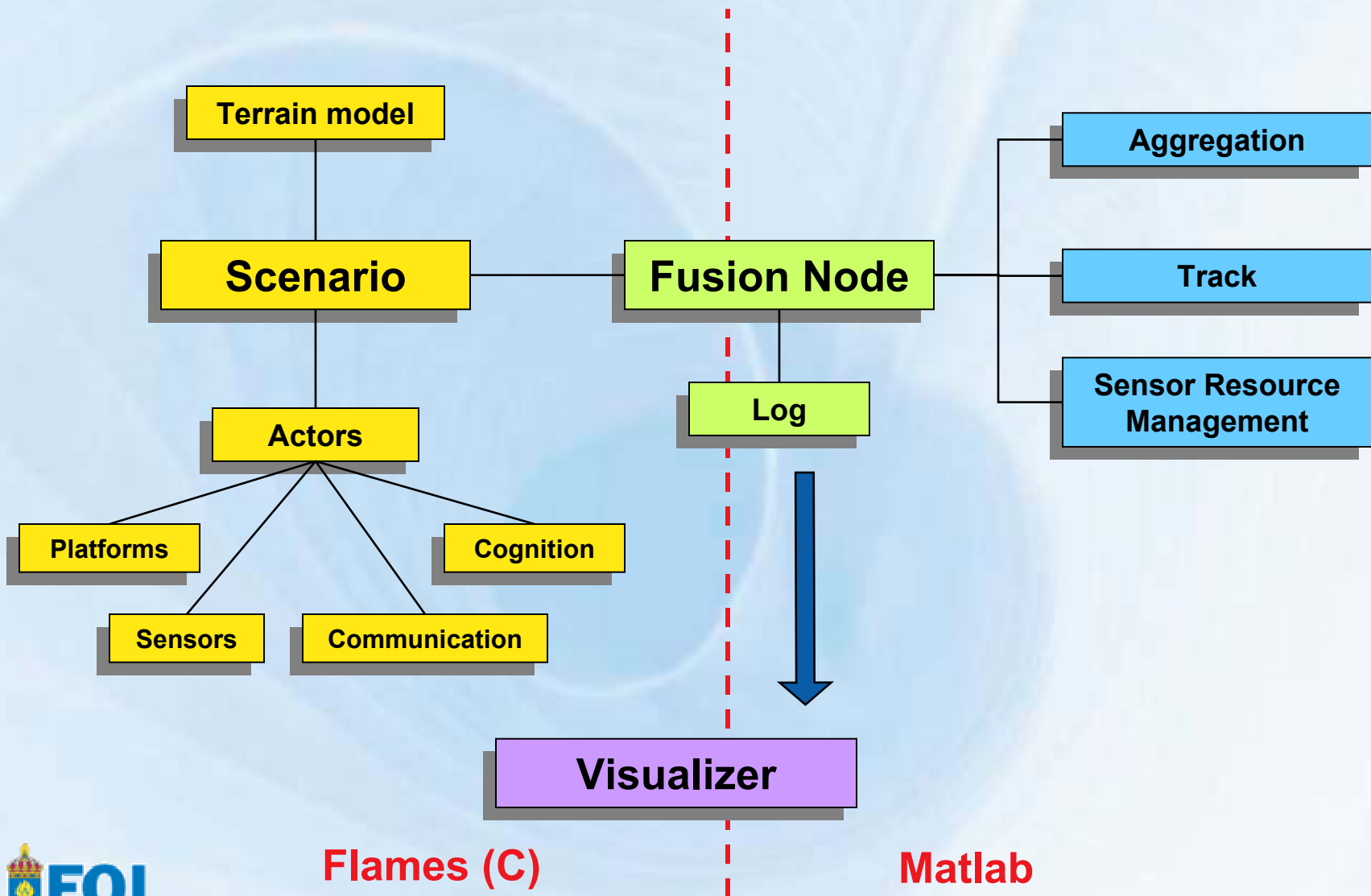
# Sensor Resource Management

- Compare pre-determined sensor allocations
- Best sensor allocation is determined by averaging over many possible future paths

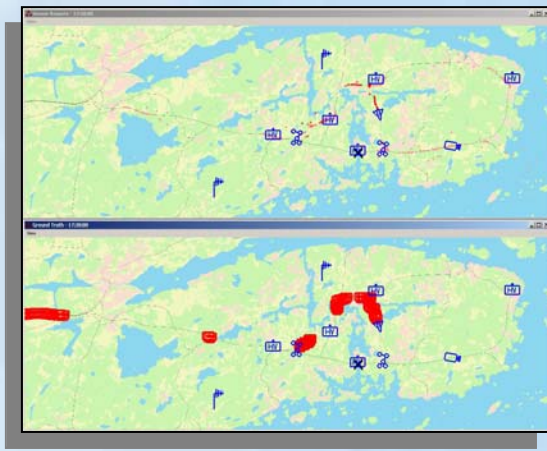
# System Description



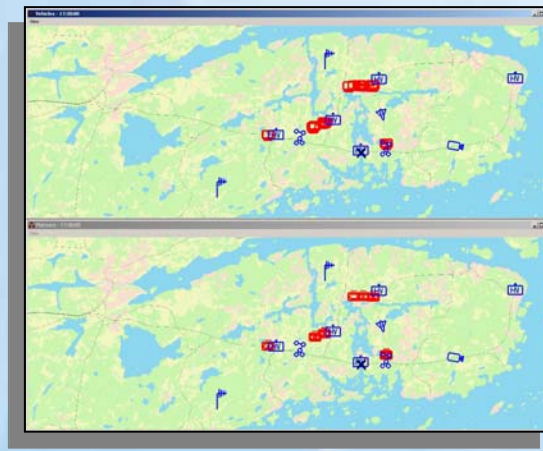
- Simulation Framework (Flames)
- Terrain model generator (Terra Vista)
- Analysis methods implemented in Matlab



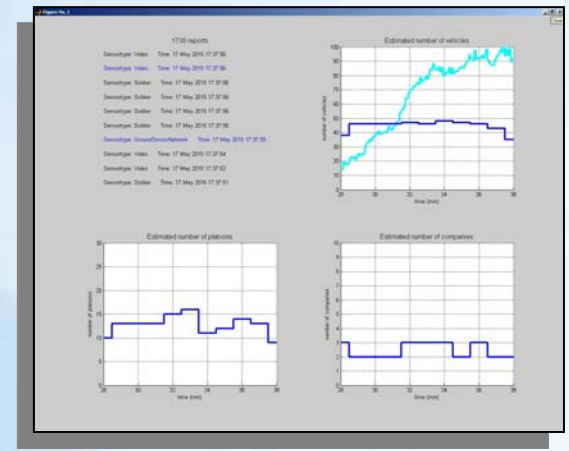
# Visualizer



**Intelligence/  
Ground truth**



**Aggregation/  
Track**



**Parameters/  
Sensor Management**



# Conclusion

- We have developed a concept demonstrator for information fusion methodology
- Focus on intelligence processing at the division level
- A demonstration of IFD03 in December 2003 for the Swedish Armed Forces was a great success

# Questions?

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